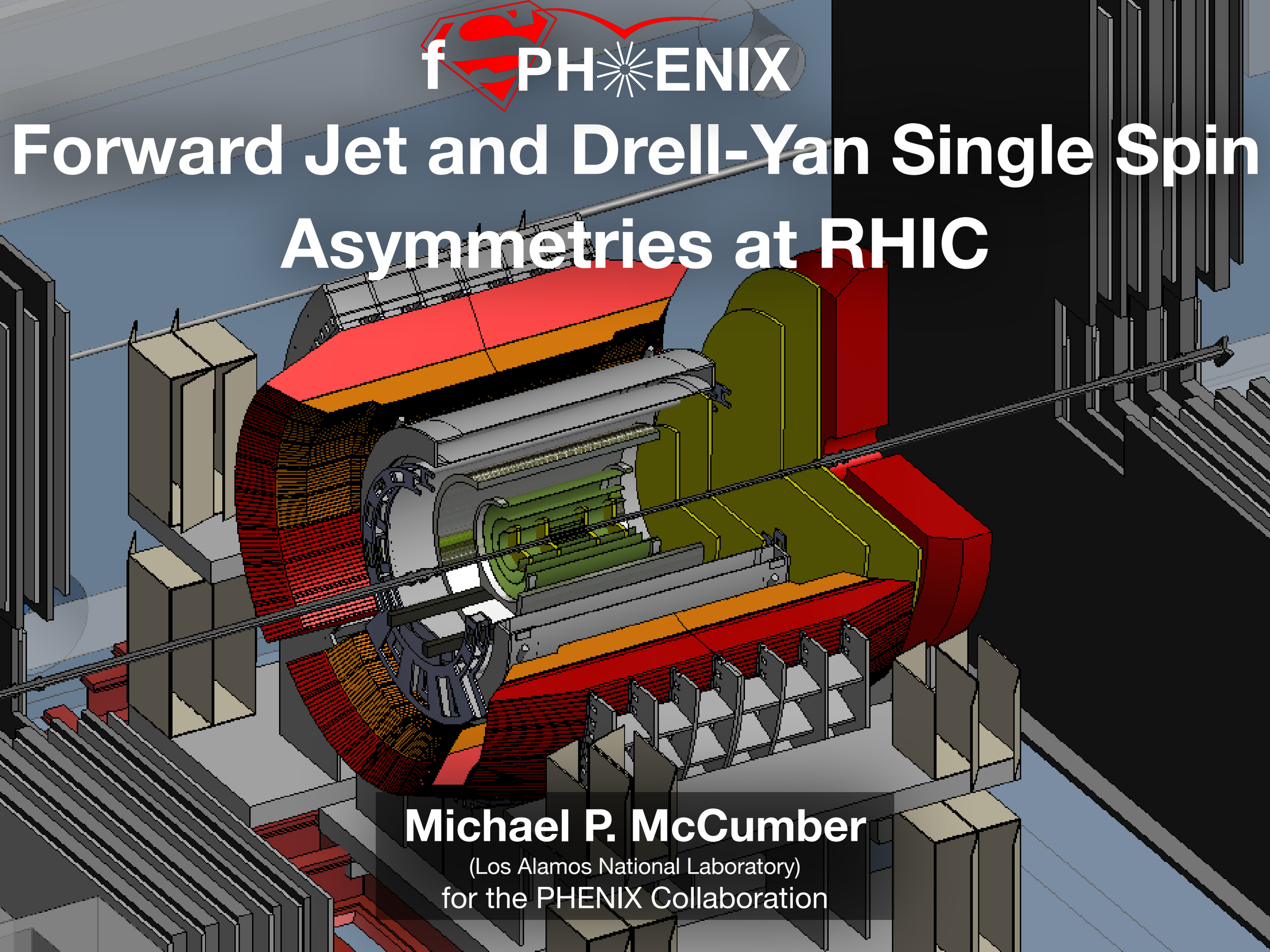


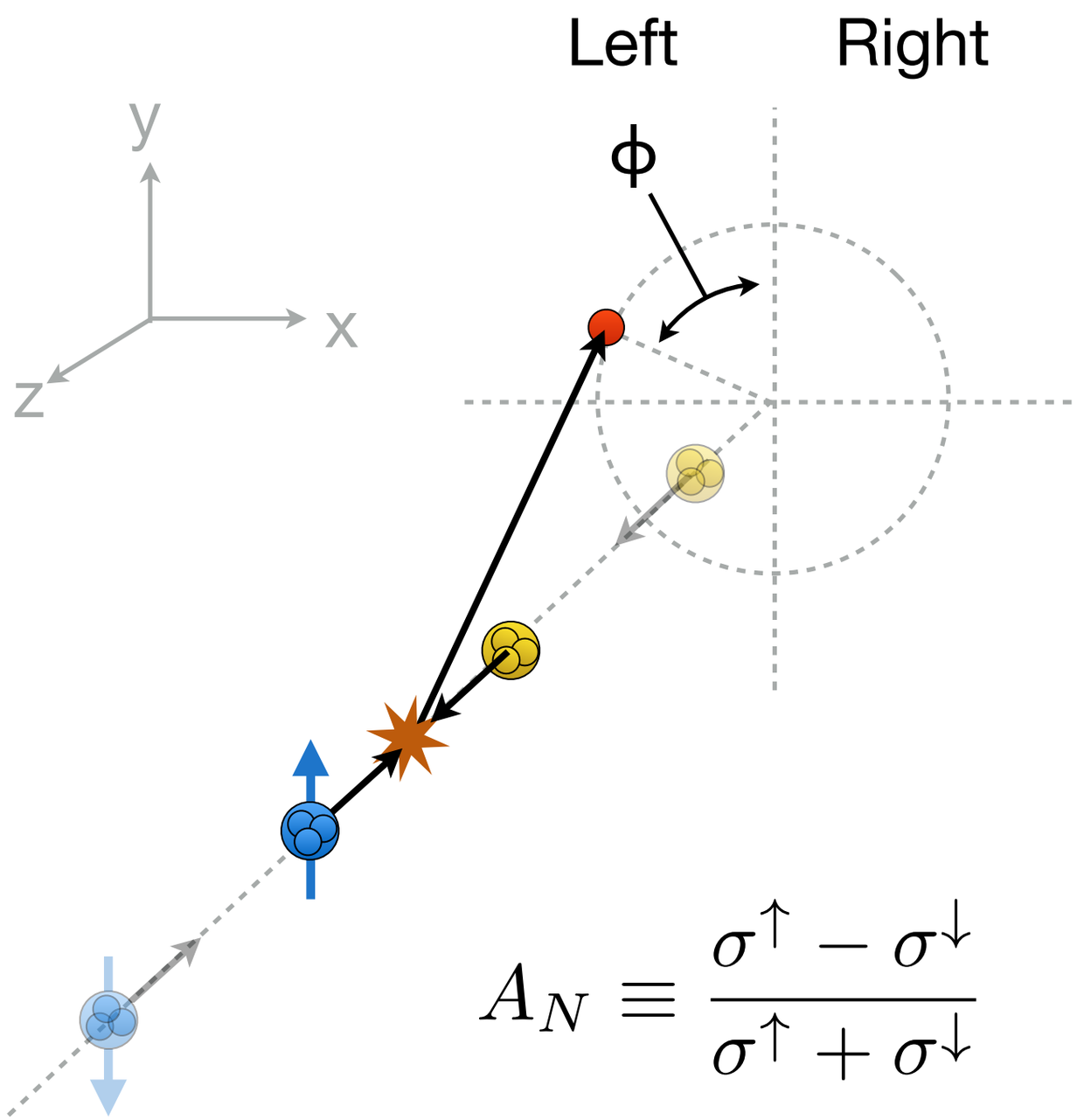
Forward Jet and Drell-Yan Single Spin Asymmetries at RHIC

Michael P. McCumber

(Los Alamos National Laboratory)

for the PHENIX Collaboration

Transverse Single Spin Asymmetry



$$A_N \equiv \frac{\sigma^{\uparrow} - \sigma^{\downarrow}}{\sigma^{\uparrow} + \sigma^{\downarrow}}$$

TSSA measured via particle production relative to proton spin direction, i.e.:

$$N(\phi) = N_0[1 + PA_N \cos\phi]$$

where P is the polarization

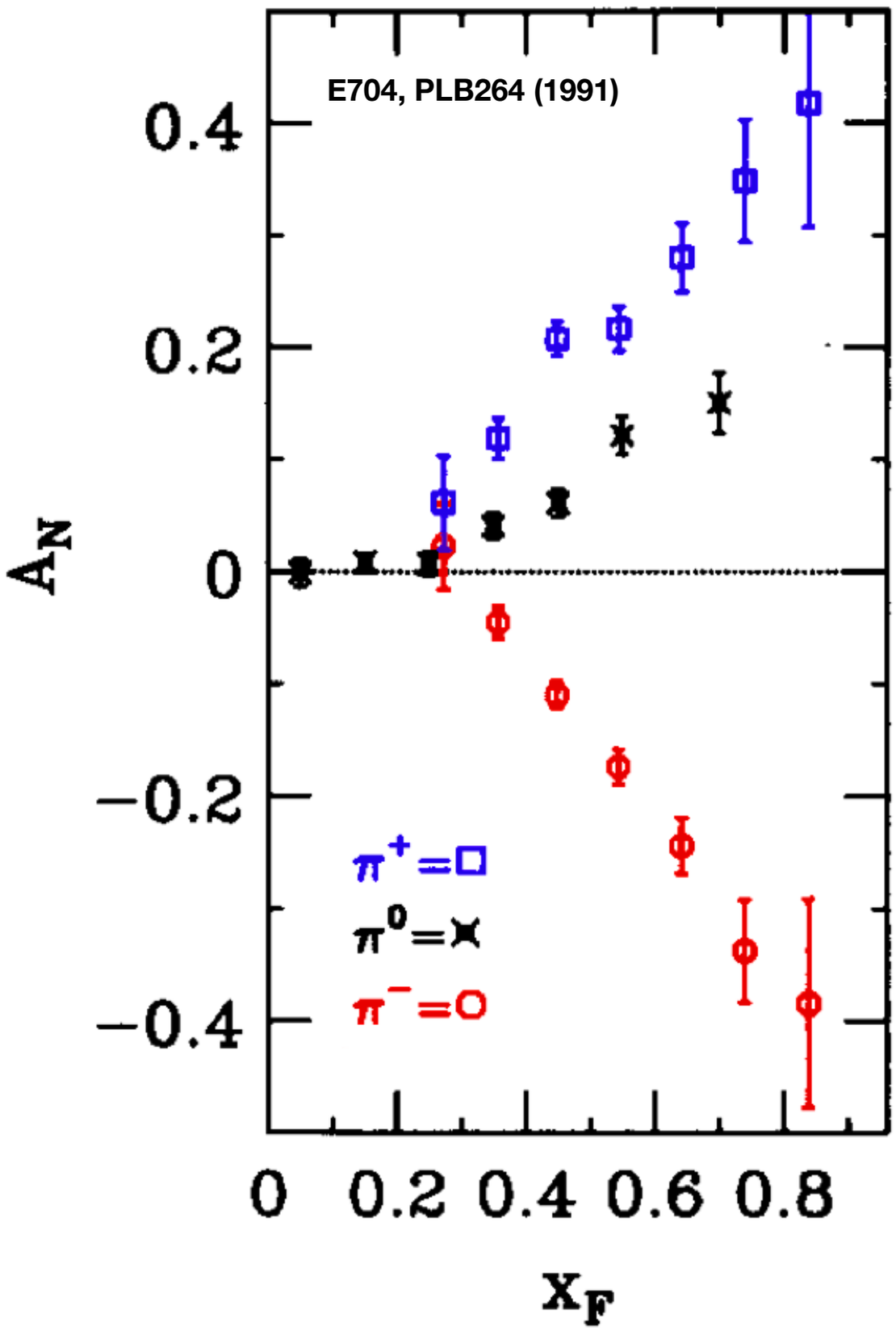
Theoretical expectations via collinear pQCD:

$$A_N \approx \frac{m_q \alpha_s}{p_T}$$

$$A_N|_{p_T = 2GeV/c} \approx 10^{-3}$$

Only small asymmetries predicted

Experimental Observations



E704 measured A_N of a polarized proton on fixed target and discovered large A_N values at large x_F

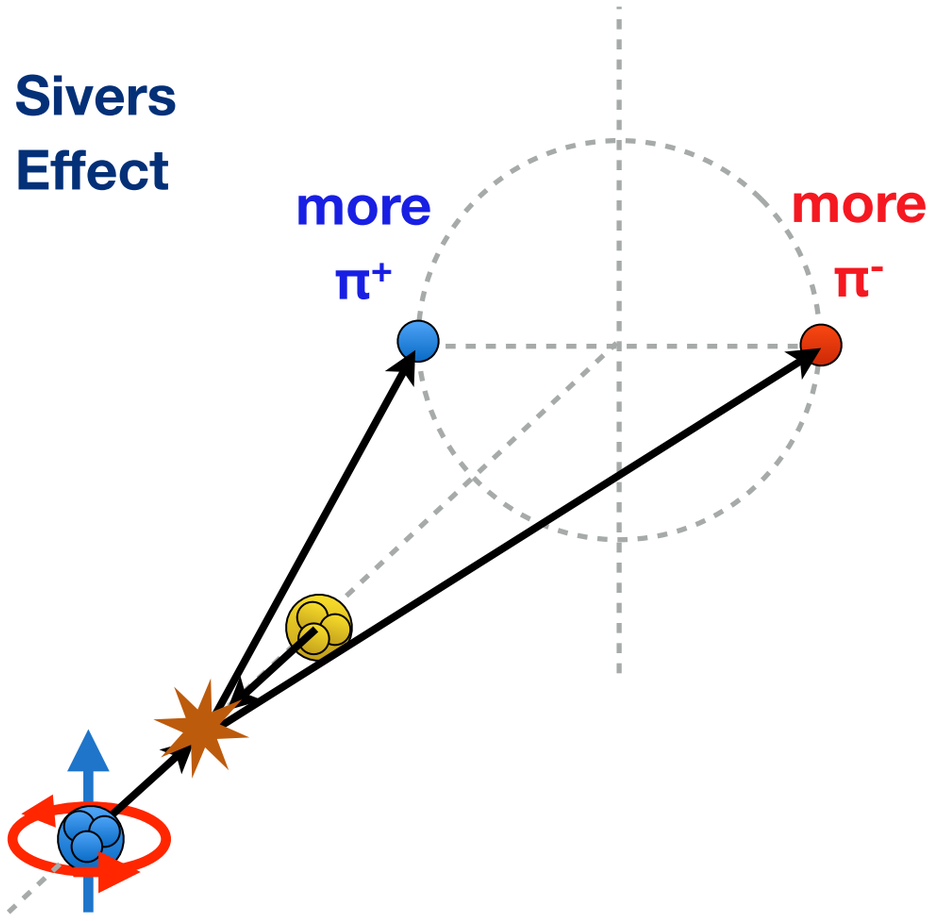
Large positive values for π^+
Smaller positive values for π^0
Large negative values for π^-

Indicative of a valence quark effect

Positive effect from up-quark
Negative effect from down-quark

Physical Explanations

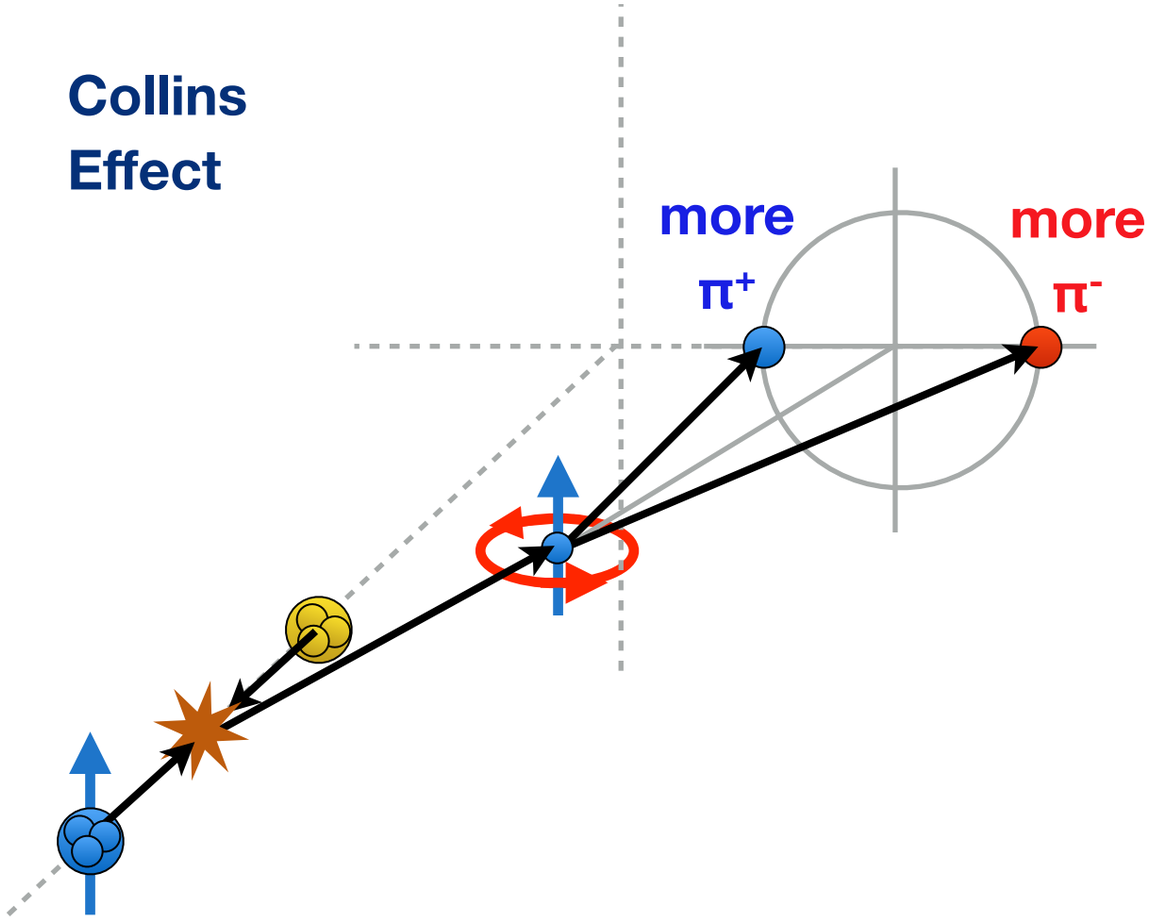
Sivers Effect



Transverse momentum dependence incorporated directly into **proton structure function**

$$\propto \bar{f}_{1T}^{\perp q}(x, k_\perp^2) \times D_q^h(z)$$

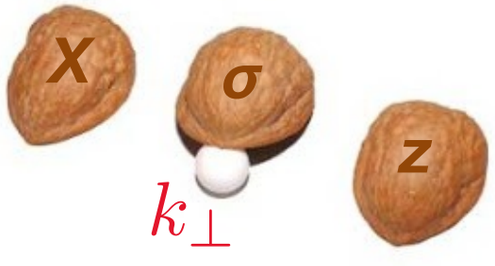
Collins Effect



Correlation between proton and quark spin + polarized quark **fragmentation function**

$$\propto \delta q(x) \times H_1^\perp(z_2, \bar{k}_\perp^2)$$

Source separation can be achieved by full reconstruction of the jet fragmentation



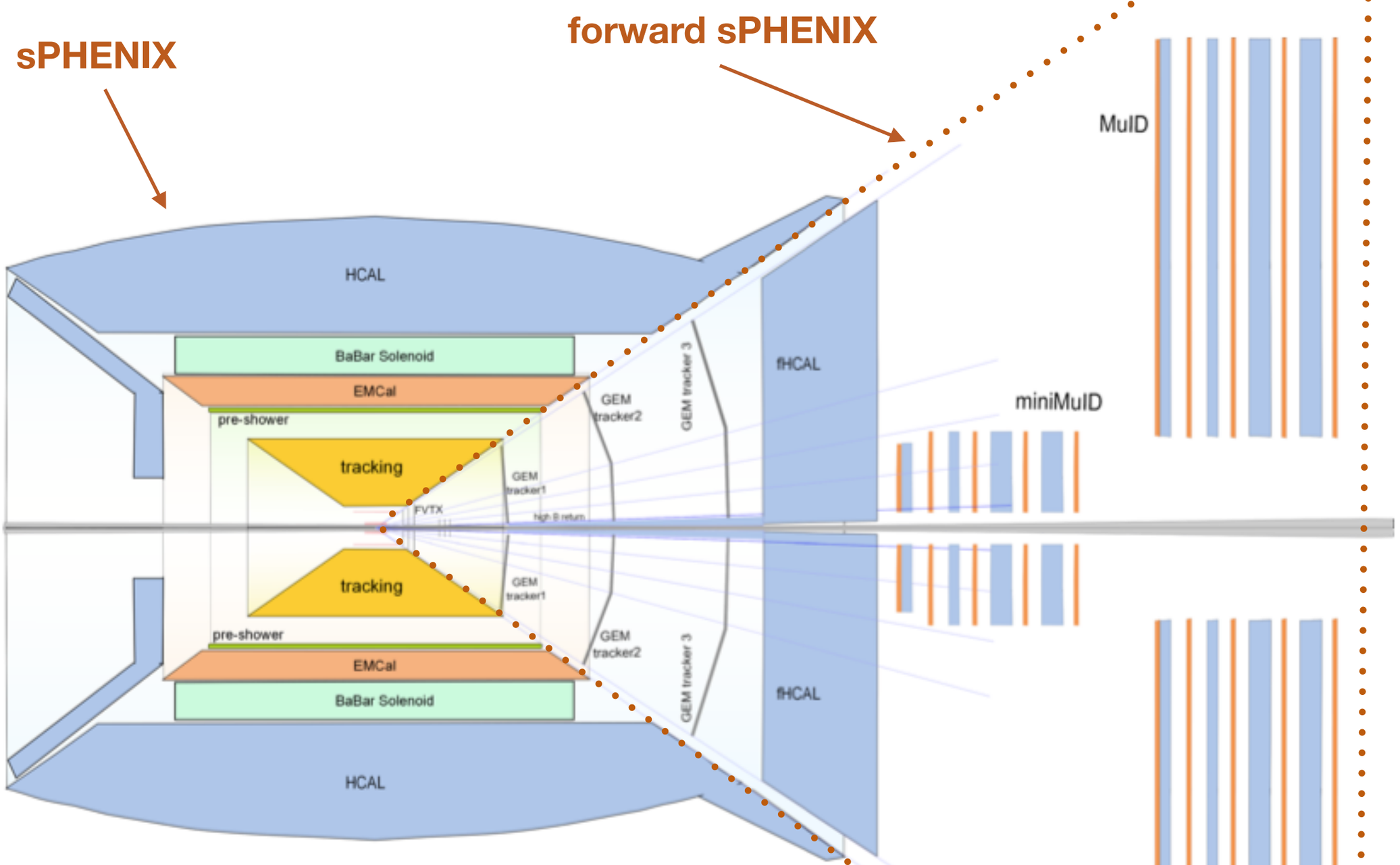
Higher-twist approach (parallel to above effects):

additional terms incorporated into extended pQCD calculation, different structure func.

predicts $A_N \sim 1/p_T$ at $p_T >> 1$ GeV/c, in contrast to Collins

and so **requires high statistics large p_T measurements (aka inclusive 'jets')**

Detector Concept



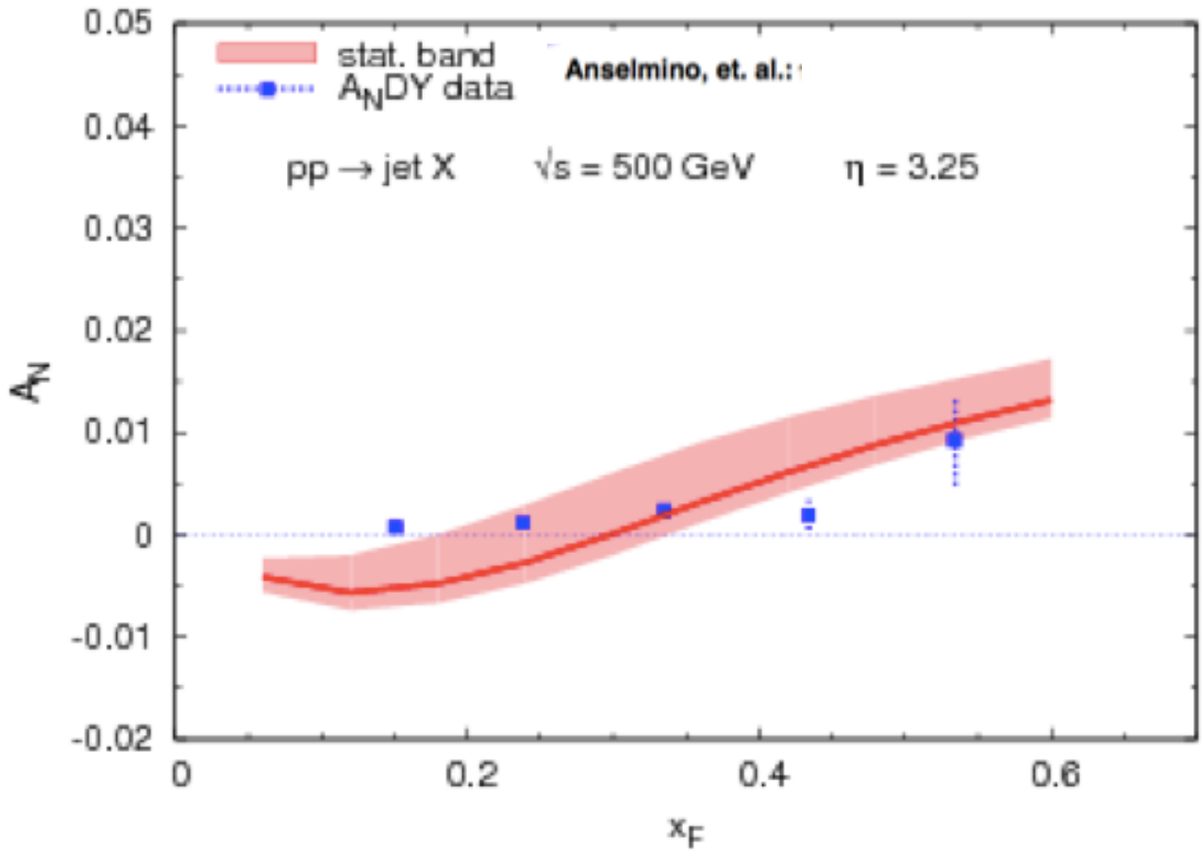
Jet Measurements:

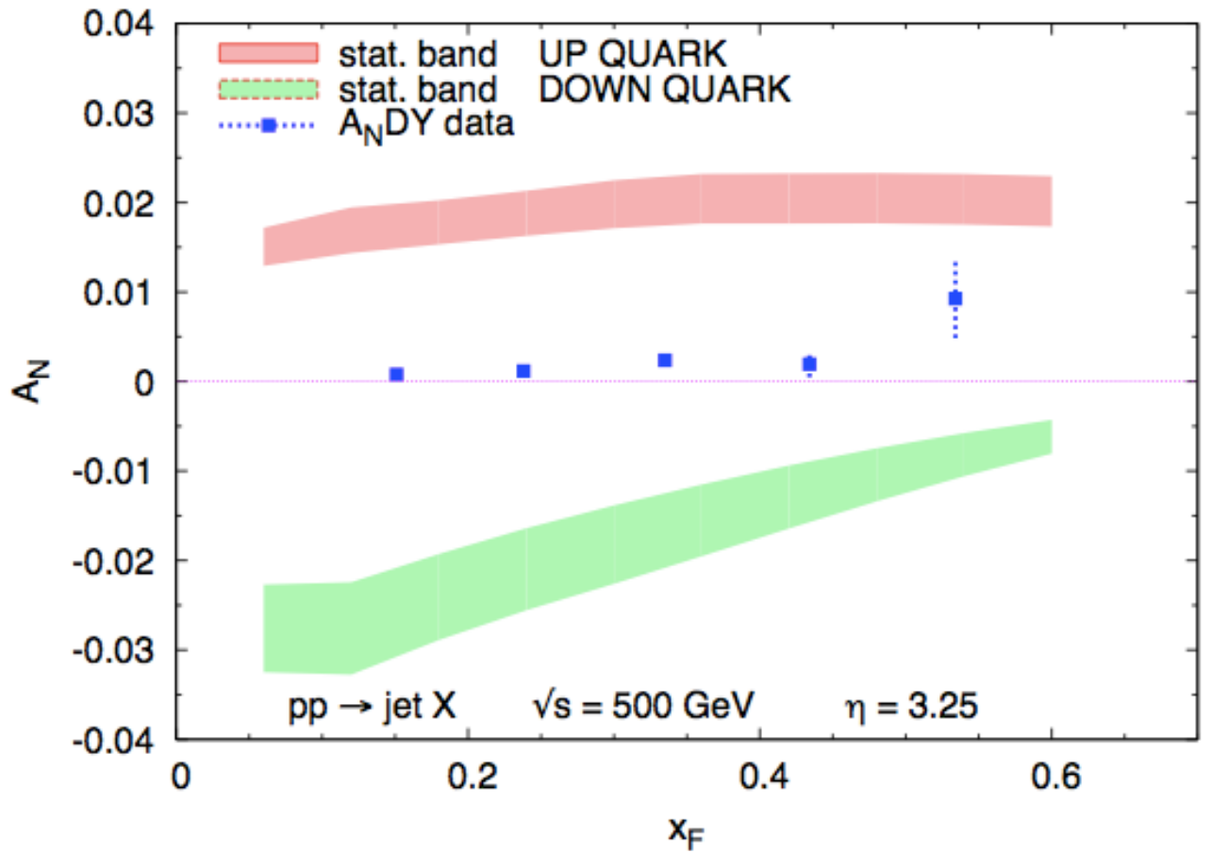
(1) hadronic calorimeter
(2) GEM tracking
(3) field shaping piston

Drell-Yan Measurements

(4) FVTX silicon
(5) MUID

Existing Jet Measurements





Like the π^0 A_N, modest jet A_N values are believed to **require a large cancellation** between contributions of up and down quark jets

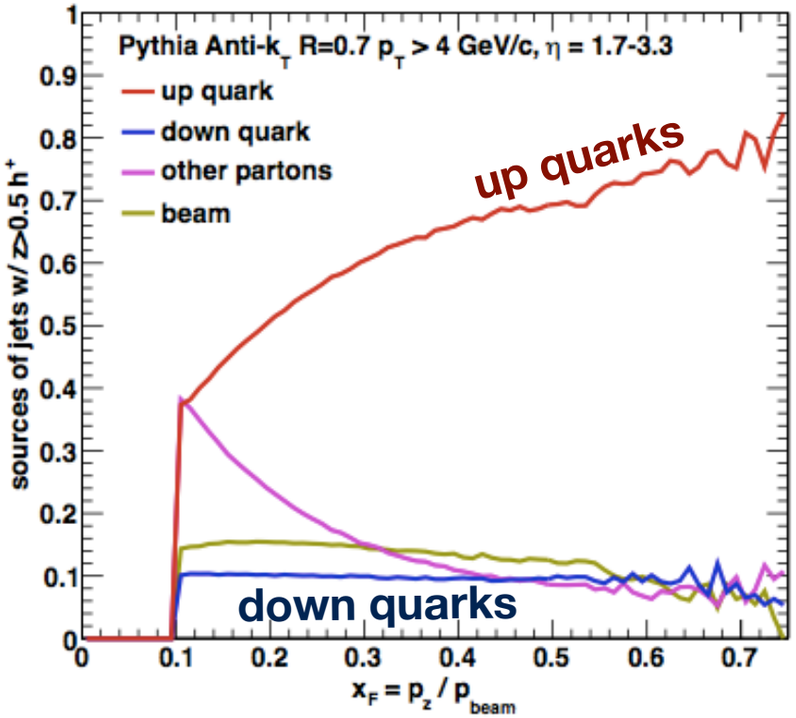
With charged particle tracking and large acceptance, **fsPHENIX will be able to separate these sources**

Changing the Mix

The Idea: cut on electromagnetic charge within the jet

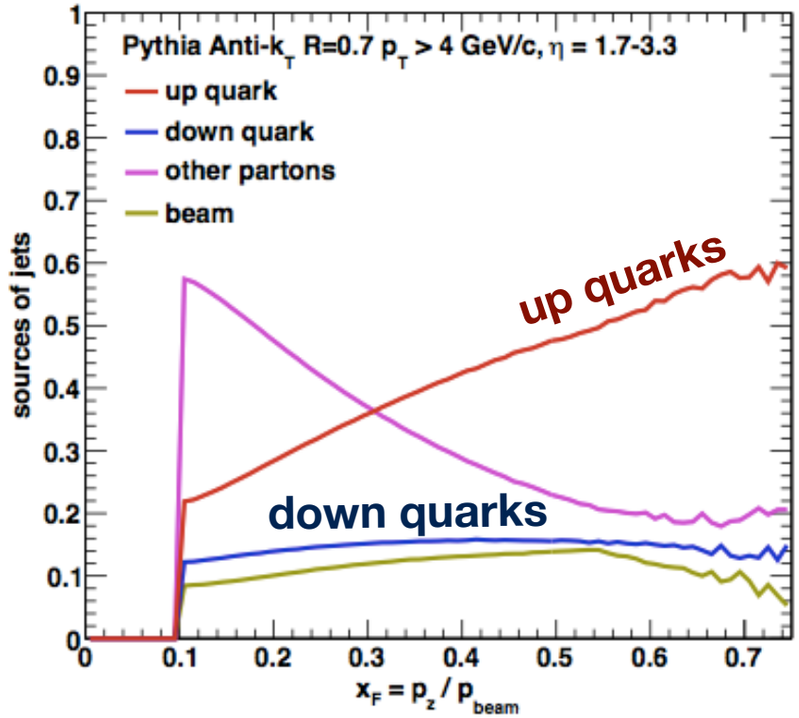
Most Primitive Approach: cut on leading charge, z > 0.5

leading positive charge



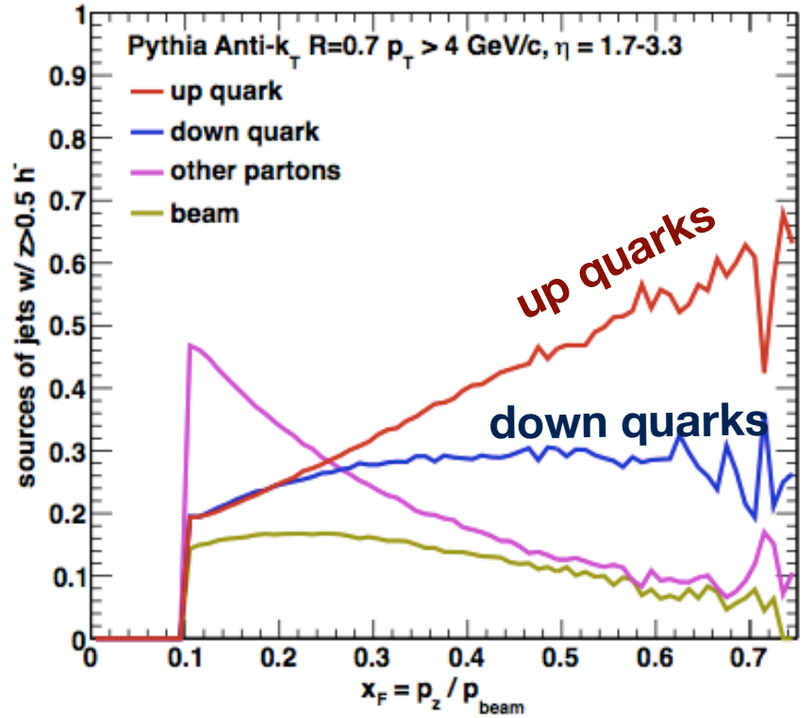
largely clean extraction of up quark jets

all jets



natural admixture of jet sources

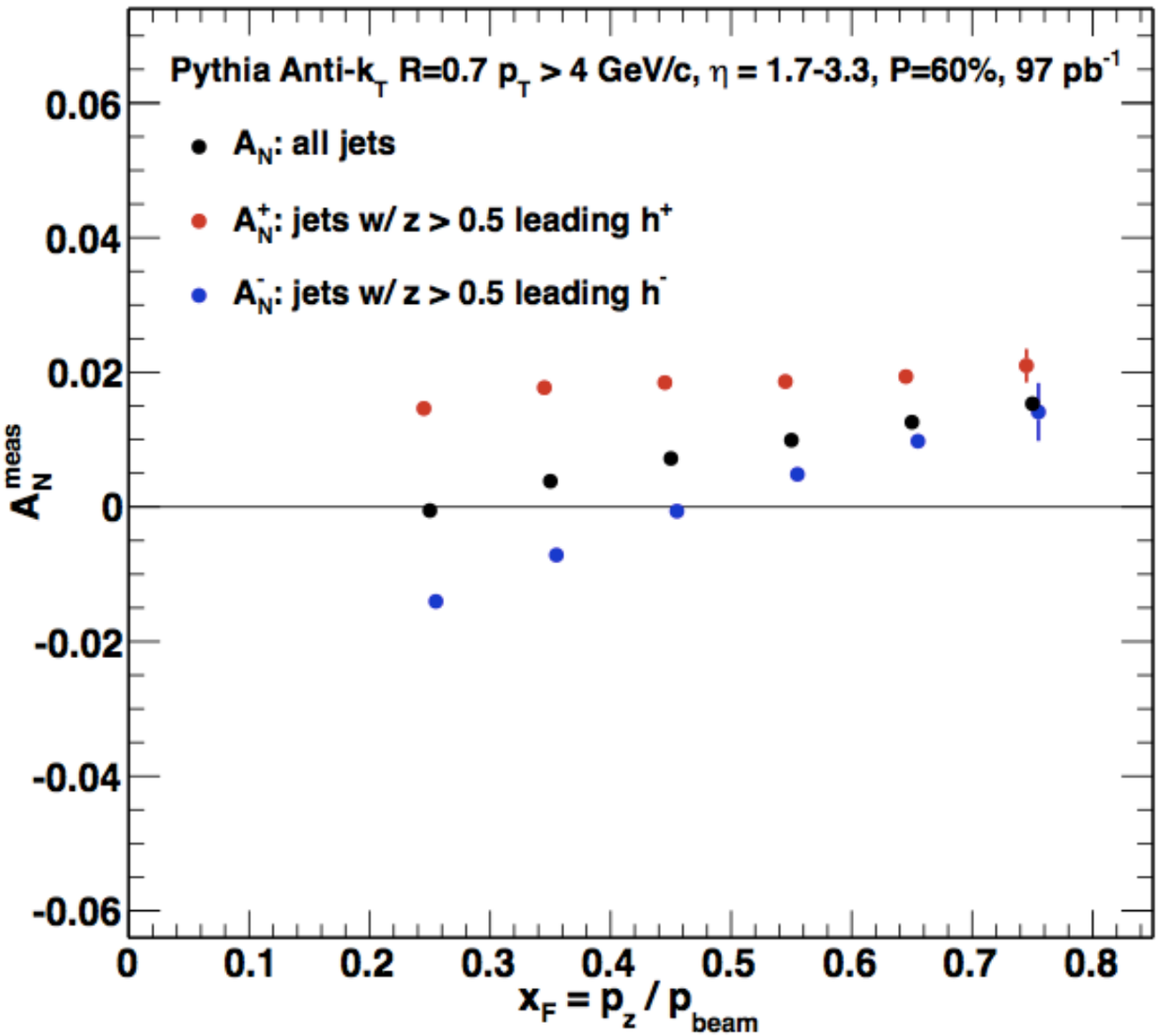
leading negative charge



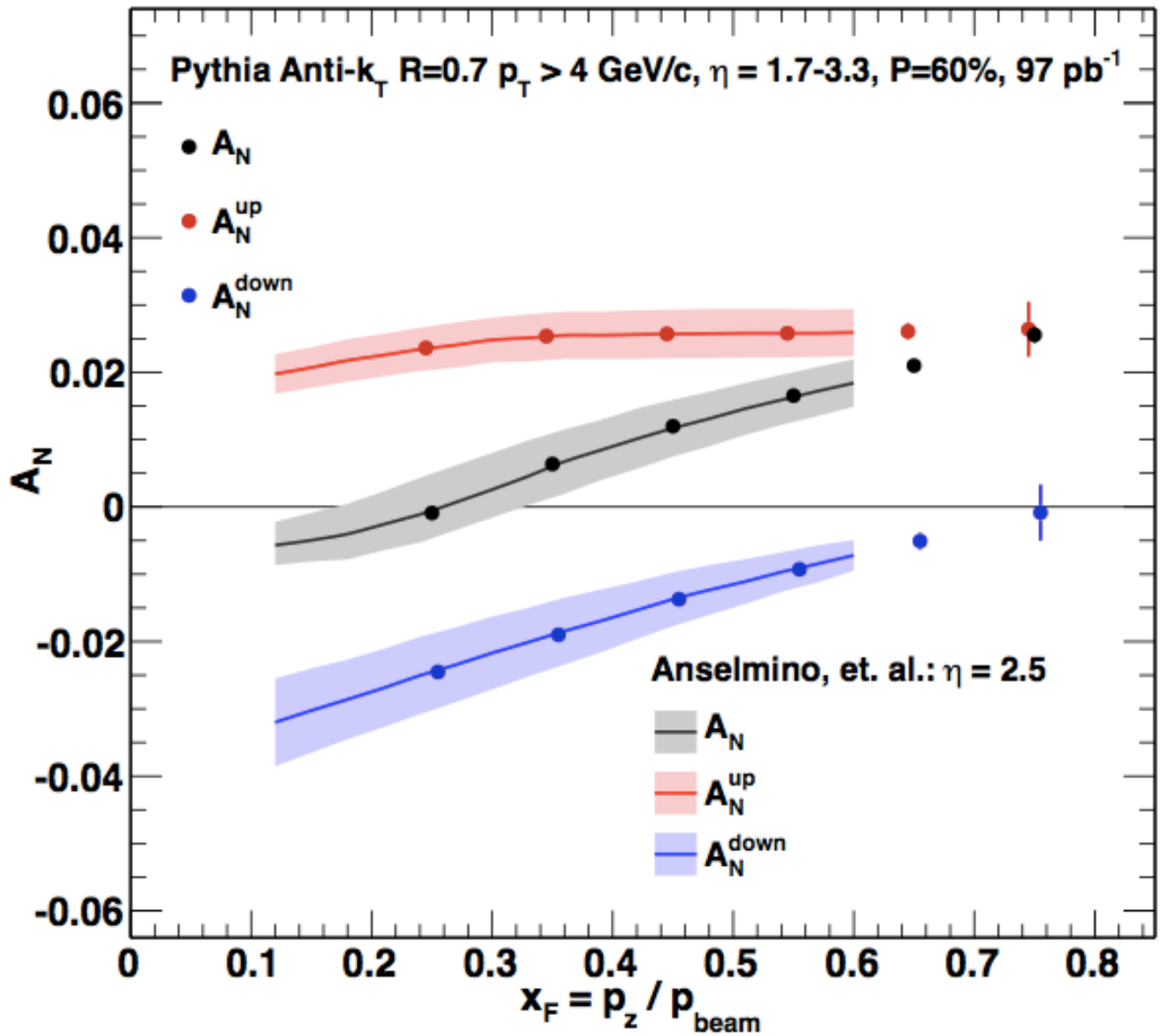
enrichment of down quark jets

Example Up & Down A_N Extraction

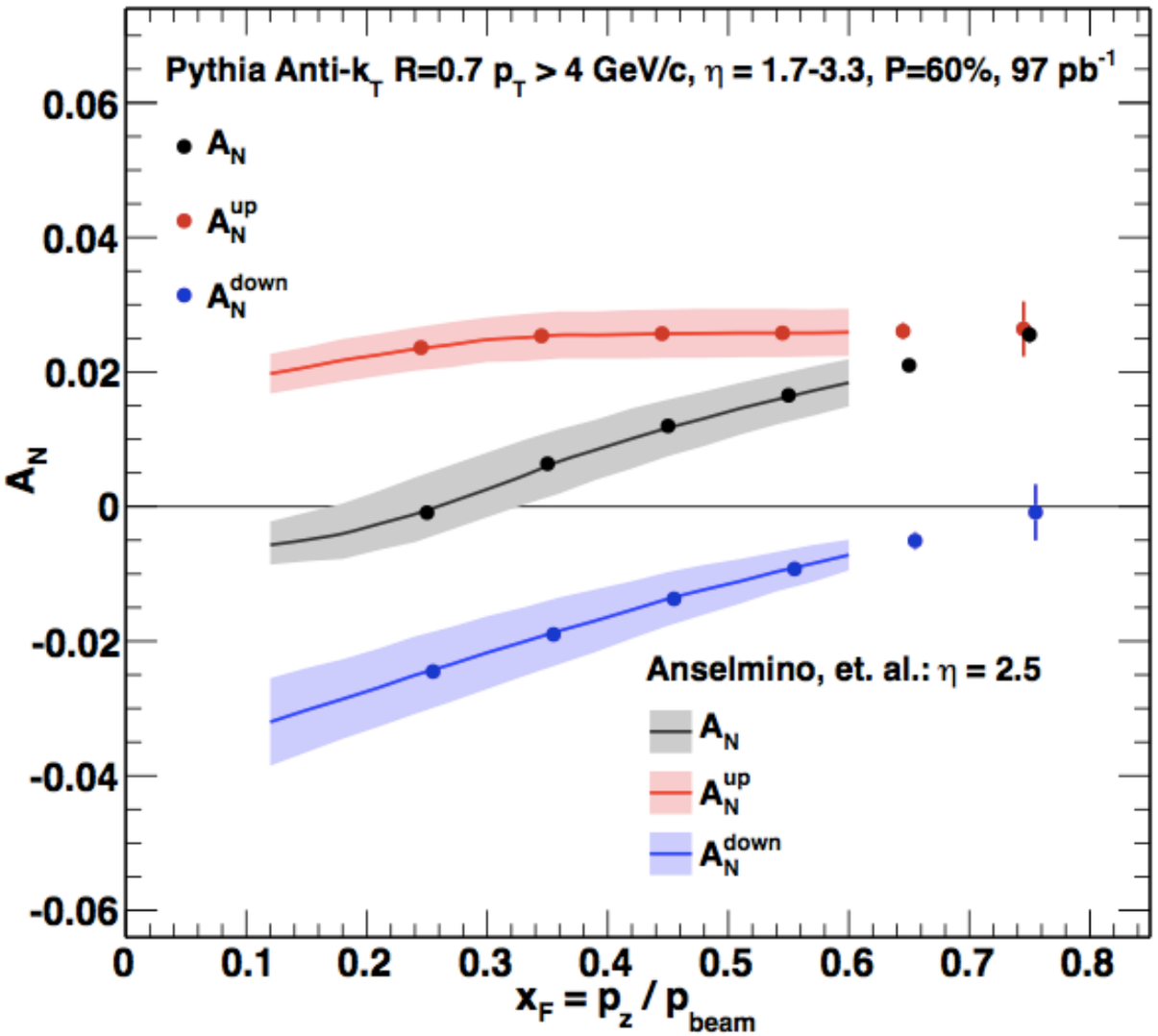
measured A_N
with leading charge sign jets

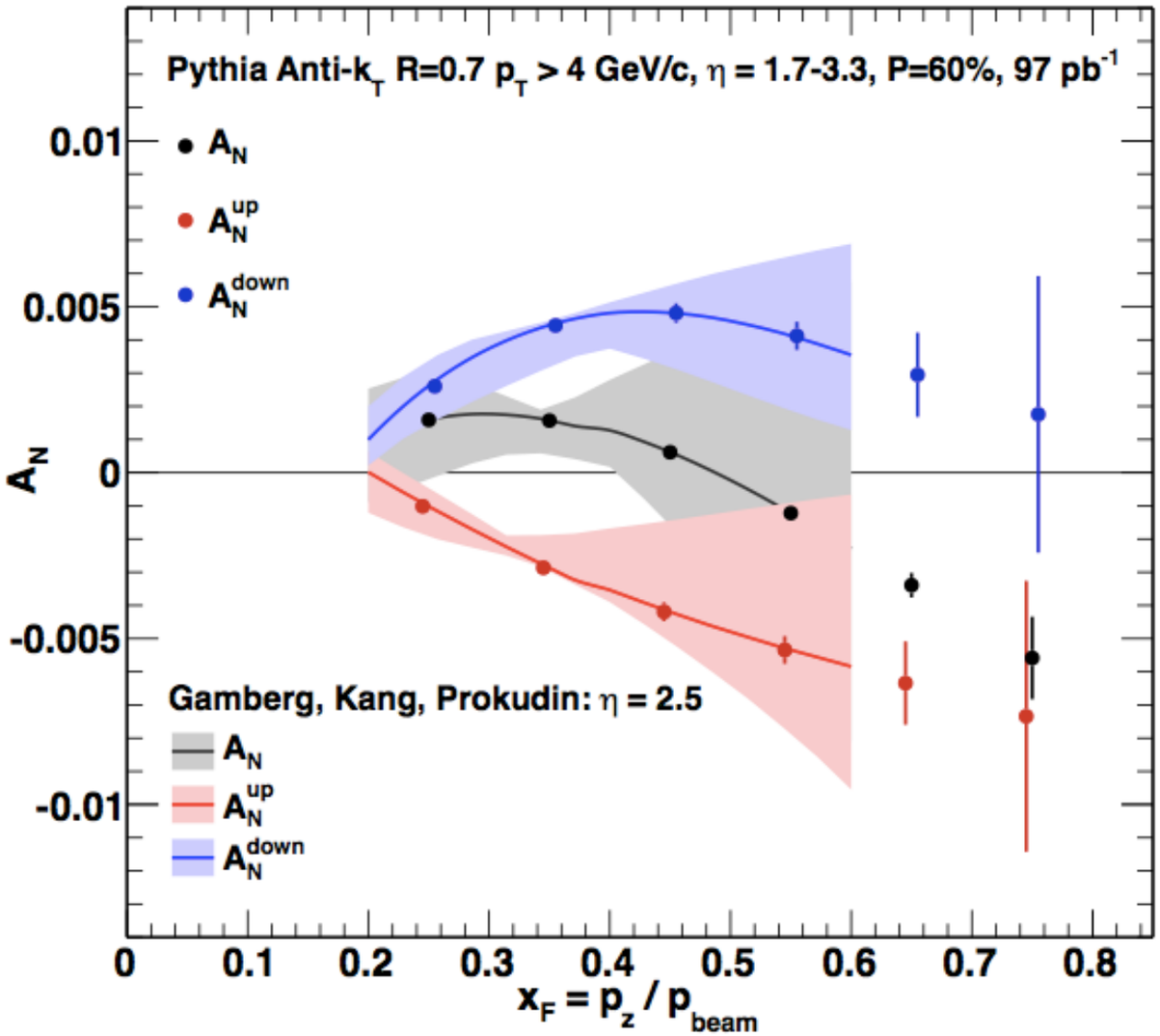


extracted quark A_N
against model inputs



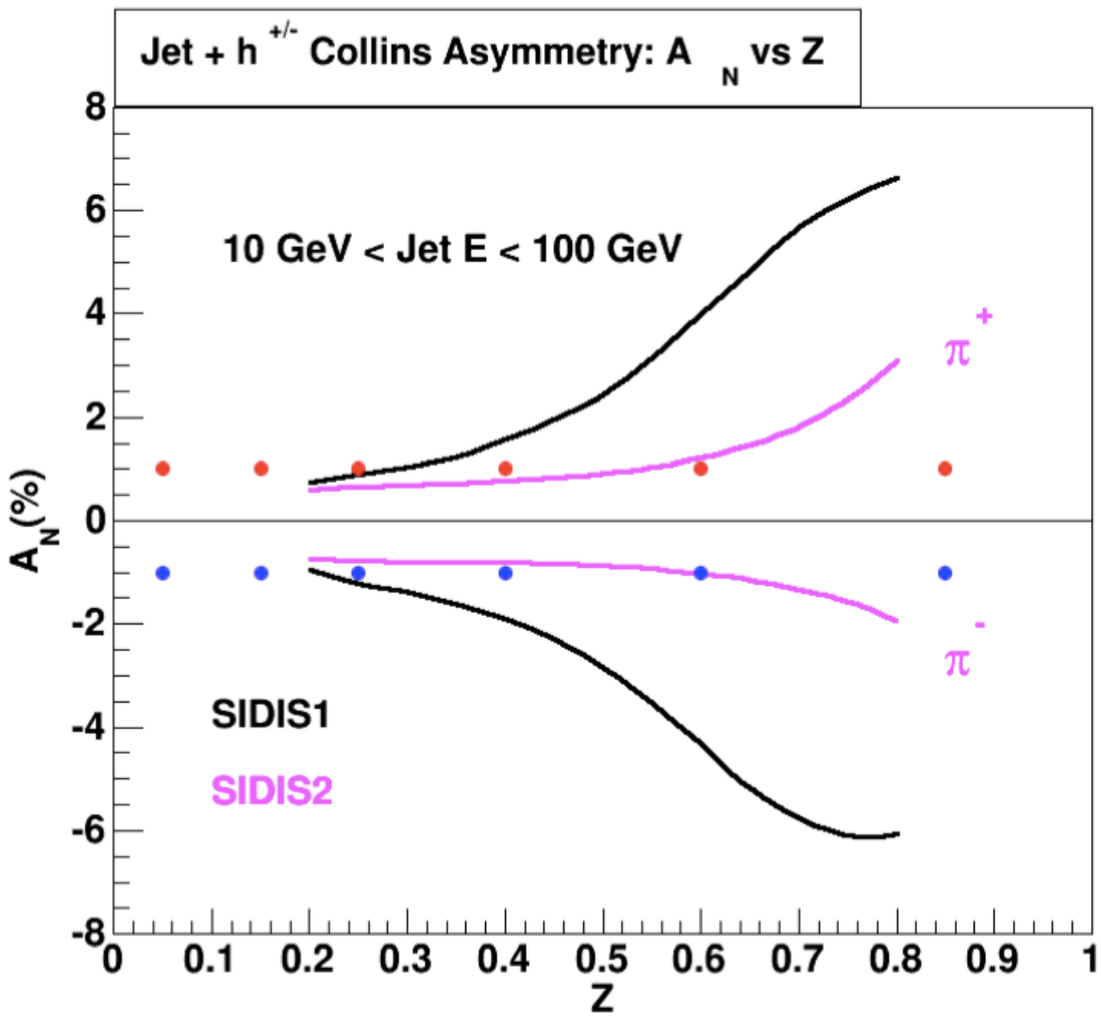
Different Models, Different Expectations



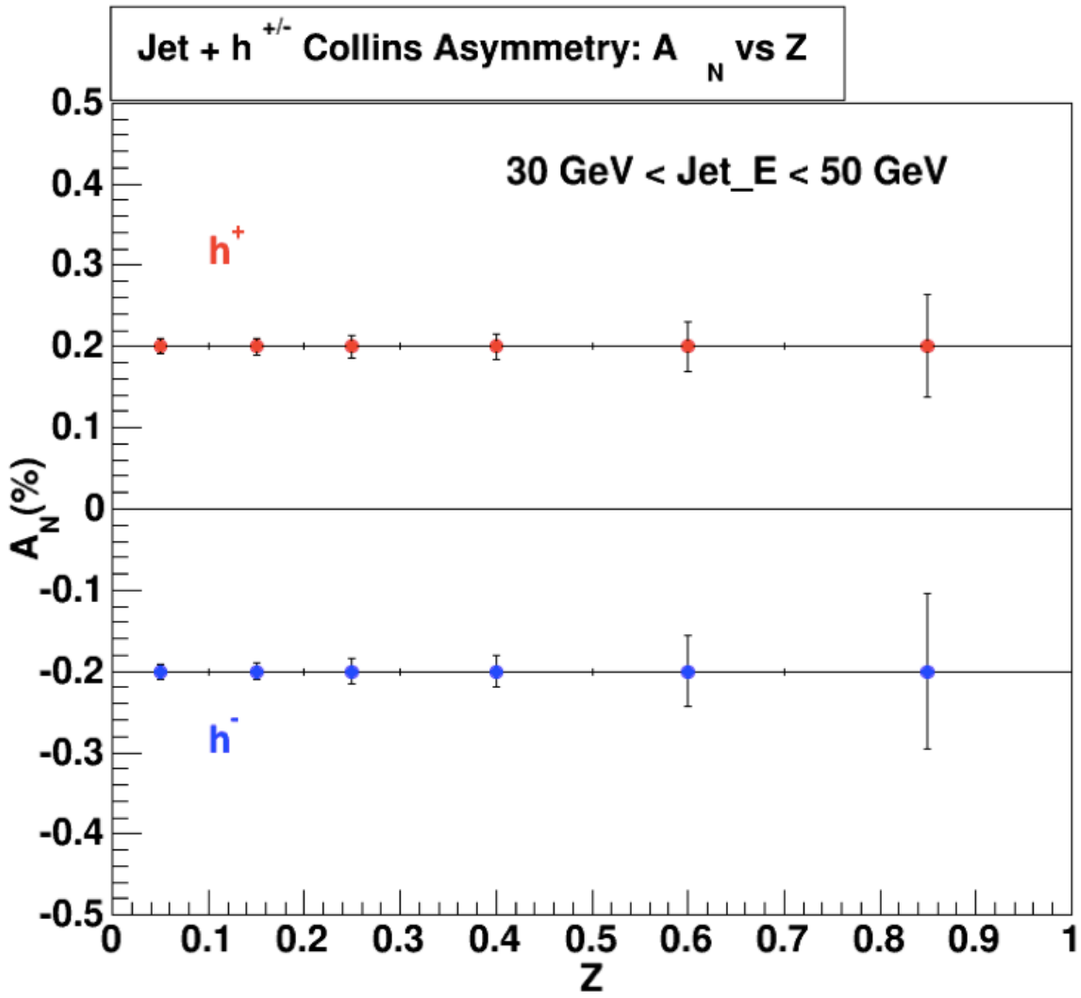


opportunity to distinguish between
leading process-dependent models

Jet Substructure



Direct access to
Collins physics within the jet

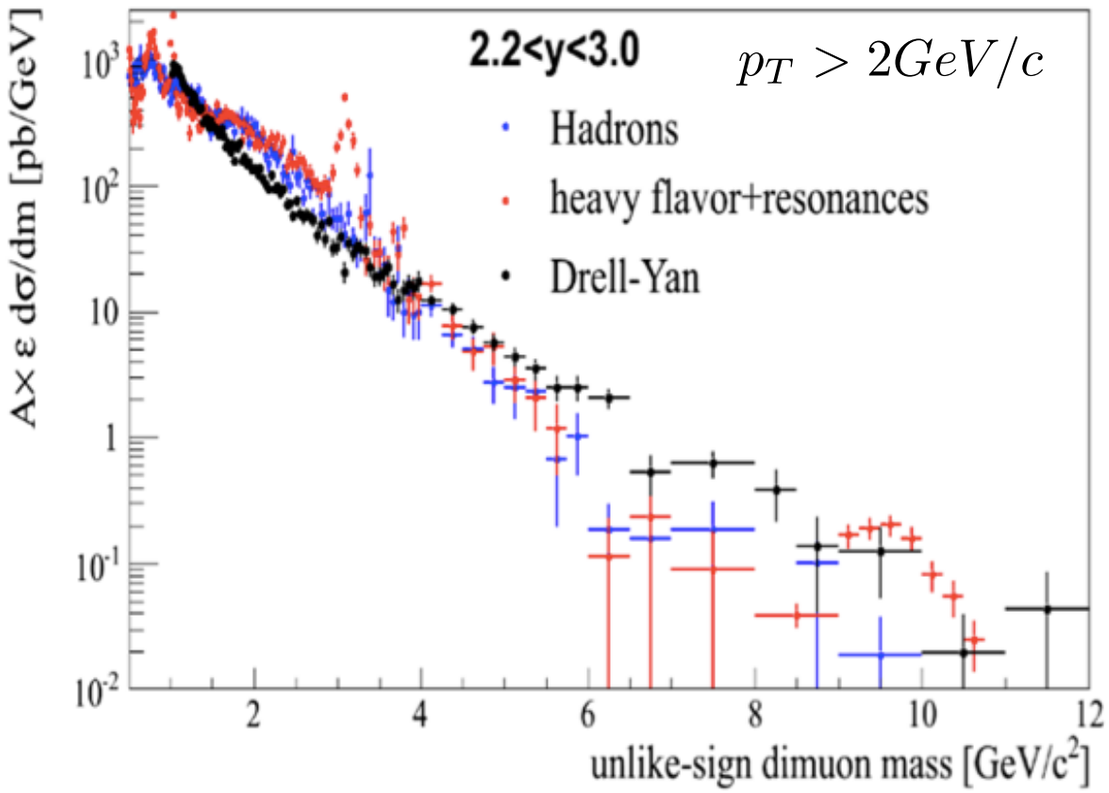


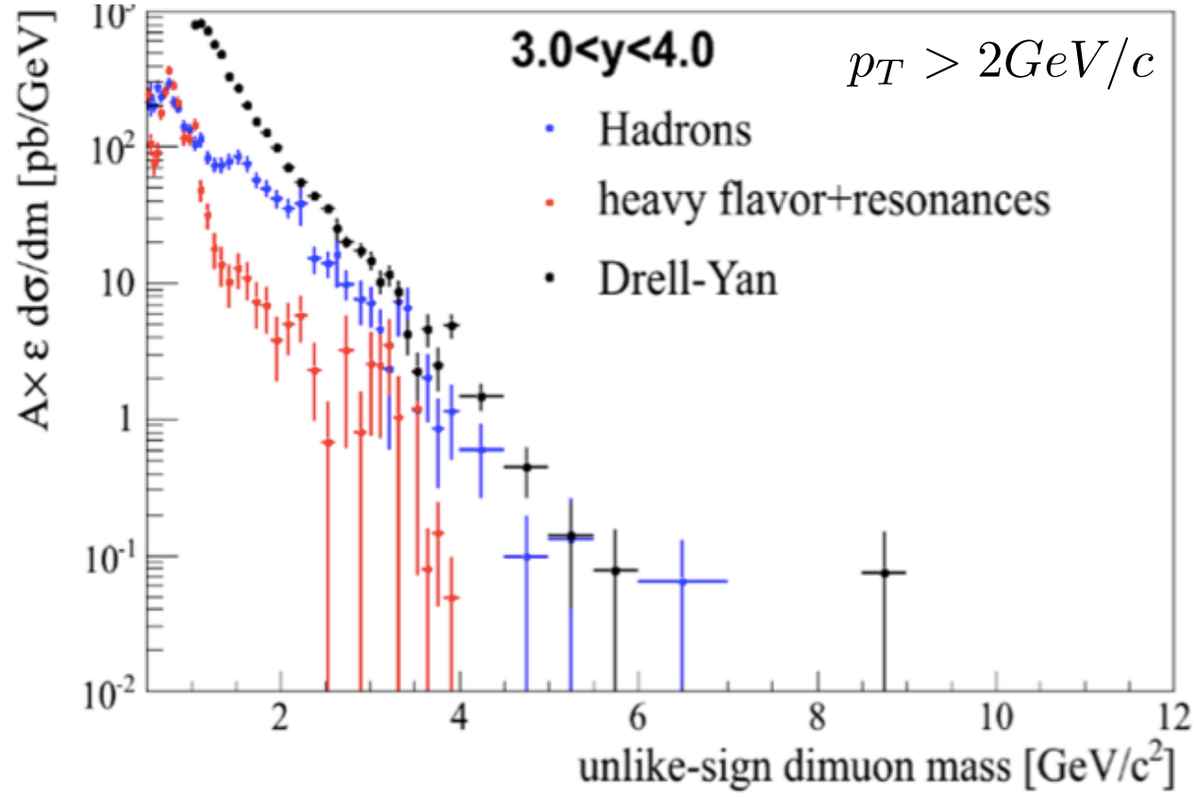
High statistics at
large jet energies

Drell-Yan

We are also interested in verification of:

$$f_{1T}^{\perp}(x, kt, Q^2)|_{DY} = -f_{1T}^{\perp}(x, kt, Q^2)|_{SIDIS}$$





at $p_T > 2$ GeV/c and large rapidity,
DY yields can be accessed at large S/B

We are exploring options to extend measurements to lower p_T

Answering Big Questions

What is the source of the large TSSA observed in p+p?

Current world data measure a mix of competing effects

New experimental data is needed!

Forward sPHENIX will determine the source of the TSSA by making the **first unambiguous simultaneous measurements** at large x of the competing effects

Will a universal description of TSSA phenomena work for both e+p and p+p?

Forward sPHENIX will examine the universality of TSSA descriptions by providing complementary p+p measurements to existing and future e+p data and by determination of Sivers-like and Collins-like contributions

More: **https://www.phenix.bnl.gov/plans.html (look for white paper link)**
http://www.phenix.bnl.gov/phenix/WWW/publish/dave/sPHENIX/pp_pA_whitepaper.pdf